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Pluteus Fr. (Pluteaceae, Agaricales) in Paraguay: morphological studies and new records

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Abstract

Four species of *Pluteus* Fr. are documented based on recently collected specimens from Alto Paraguay and Central Department, which correspond to the Pantanal and Humid Chaco ecoregions, respectively. *Pluteus fibulatus* Singer, *P. longistriatus* (Peck) Peck, *P. petasatus* (Fr.) Gillet, and *P. triplocystis* Singer are newly recorded species of the mycobiota of Paraguay; *P. triplocystis* is also a newly recorded for South America. Descriptions and photographs of both macro- and microscopic features of each species are included along with a brief discussion on their taxonomy, ecology, and distribution.

Key words

Fungi, mycobiota, Pantanal, South America.

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Introduction

Based on traditional morphological concepts (Pegler 1983, Singer 1986), Pluteaceae Kotl. & Pouzar include 3 genera with free and pinkish lamellae: *Chamaeota* (W.G. Sm.) Earle, characterized by basidiomata with annulus but without volva, *Volvariella* Speg., with volva but lacking of an annulus, and *Pluteus* Fr., characterized by the absence of both annulus and volva. Based on phylogenetic analyses with molecular sequence data, the recognition of *Chamaeota* was questioned by Minnis et al. (2006), who transferred 2 species with annulus from this genus to *Pluteus*. The definition of *Volvariella* has also been modified based on molecular sequence data since Justo et al. (2011a) proposed a new genus, *Volvopluteus* Vizzini, Contu & Justo, which was segregated from *Volvariella* on account of differences in the basidiospore size and pileipellis structure.

Pluteus is a monophyletic genus (Moncalvo et al. 2002, Justo et al. 2011a) with approximately 300 widespread species (Kirk et al. 2008). They are mostly saprotrophic and found on wood with a high degree of decomposition but also in humus, sand, and the tissues of living plants (Pegler 1983). The genus has a global distribution

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and is very common in boreal to tropical regions (Pegler 1983, Justo et al. 2014, Menolli et al. 2014). The type species of the genus is *Pluteus cervinus* (Schaeff.) P. Kumm., which is common in temperate forests in Eurasia and eastern North America. It is characterized by pluteoid basidiomata which are variable in size and pileus color, ranging from white to brown, gray-brown or orange-brown. *Pluteus cervinus* mostly grows in angiosperm wood of temperate forests and is rarely found growing in conifers. It is characterized by metuloidal pleurocystidia of entire hooks, and without clamp-connections on pileipellis hyphae (Justo et al. 2014).

Singer (1959, 1986) considered 3 sections in the infrageneric classification of *Pluteus*, based on the arrangement of the pileipellis and the pleurocystidia type. Justo et al. (2011b) later complemented this classification with molecular sequence data. *Pluteus* sect. *Pluteus* is characterized by metuloidal pleurocystidia and a pileipellis formed by a cutis. *Pluteus* sect. *Hispidoderma* Fayod has thin-walled pleurocystidia and a pileipellis composed of elements forming a trichoderm or a hymenoderm. *Pluteus* sect. *Celluloderma* Fayod. is characterized by non-metuloid pleurocystidia or with the pleurocystidia absent and, in most cases, with a pileipellis composed of short clavate or spheropedunculate cells, mixed or not with elongated cystidioid elements, but also including taxa characterized by the presence of the annulus and/or pileipellis as a cutis.

In South America, the genus *Pluteus* has been fairly well studied and recorded from Argentina (Singer 1952, 1954a, 1956, 1959, 1962, 1969, Singer and Digilio 1952, Horak 1964, Raithelhuber 1987, 1991, Lechner et al. 2006), Brazil (mainly by Singer and Digilio 1952, Singer 1954b, 1956, 1959, 1973, 1989, Wartchow et al. 2004, 2006, Menolli and Capelari 2010, 2014, 2017, Menolli et al. 2010, 2014, 2015a, 2015b, 2016, Dias and Cortez 2013), Bolivia (Singer 1959), Chile (Singer 1959, 1969, Horak 1964), Colombia (Singer 1973), Ecuador (Singer 1978, Reid et al. 1981), French Guyana (Courtecuisse 1991), and Venezuela (Dennis 1953, 1970, Singer 1962, Pegler 1983). As there are no records of Pluteaceae from Paraguay, 4 species of *Pluteus* are recorded from Paraguay for the first time, contributing to the knowledge of agaricoid mycobiota in the country.

Paraguay comprises 2 distinct geographical regions, the eastern and the western, which are separated by the Paraguay river. The western region is also known as the Chaco. The Chaco region includes 3 ecoregions: Humid Chaco, Dry Chaco, and Pantanal. The ecoregions of eastern Paraguay include in the Humid Chaco, Atlantic Forest, and Cerrado (Dinerstein et al. 1995). The Pantanal in the Chaco region comprises wetlands and floodplains where the vegetation is composed of a low stratum of herbaceous and *Copernicia alba* Morong forests adapted to periodic and prolonged flooding (Hamilton 1999).

Here, we present the new records and morphological descriptions of 5 species of *Pluteus* collected in the Pantanal and Humid Chaco ecoregions of Paraguay. Four species are newly reported from Paraguay and 1 for the first time from South America.

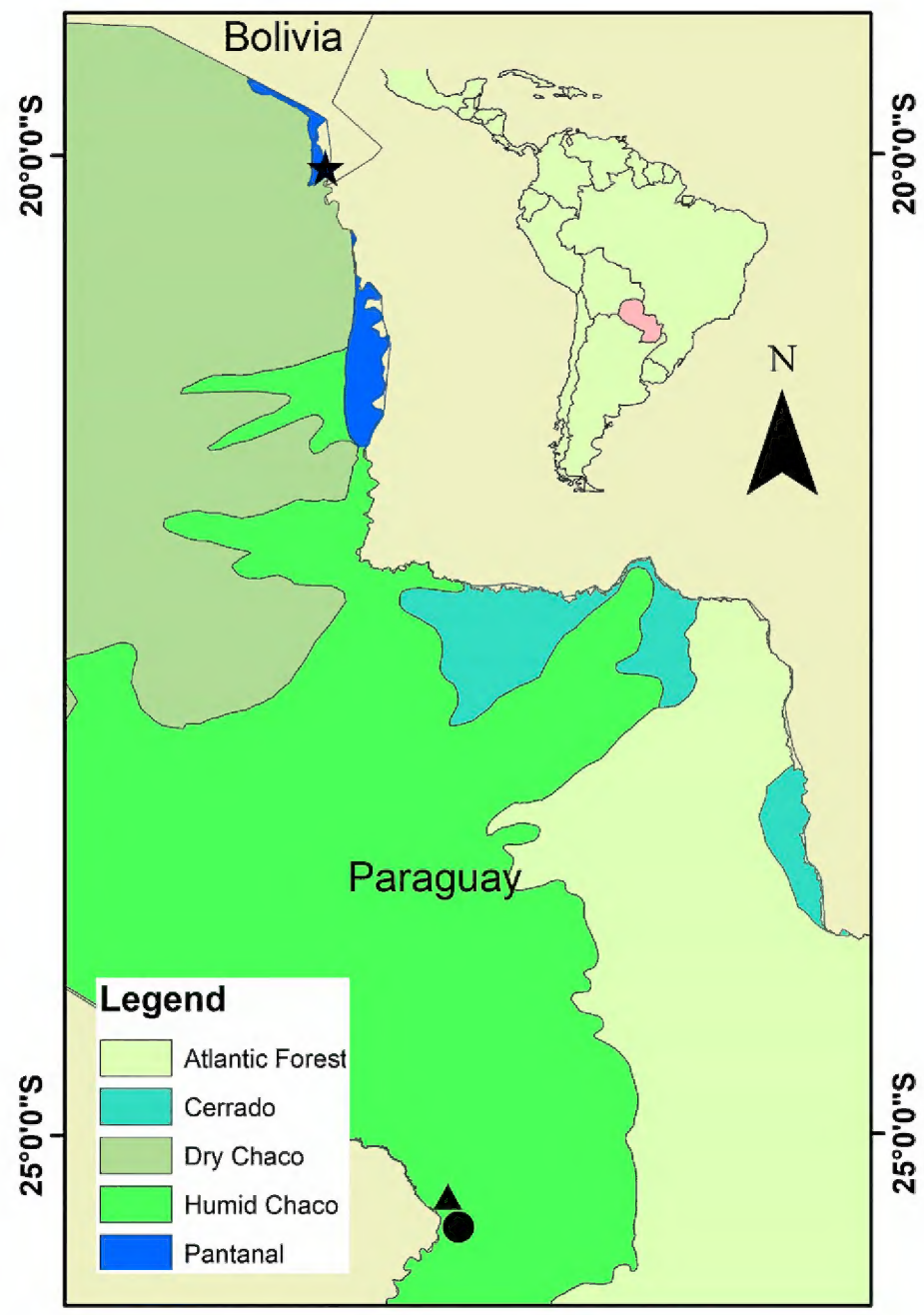

Figure 1. Distribution map of *Pluteus* species in subtropical Paraguay with the limits from each ecoregion. *Pluteus fibulatus*, *P. petasatus*, and *P. triplocystis* from the Humid Chaco ecoregion (in lime green) and *P. longistriatus* from Pantanal ecoregion (in blue), the collection sites are indicated by black figures: circle for *P. fibulatus* and *P. triplocystis*; triangle for *P. petasatus* and star for *P. longistriatus*.

Methods

The samples studied were collected in the Estación Biológica 3 Gigantes, Bahía Negra city, Alto Paraguay Department, and in 2 anthropologically modified areas in the Eastern Region: Campus Universitario, Universidad Nacional de Asunción, San Lorenzo city, Central Department, and Guarambaré city, Central Department. Macroscopic data of size, shape, and color refer to fresh material. For microscopic study, dried material was rehydrated in potassium hydroxide (KOH) (5%) and stained with phloxine (1%) and Congo red (1%); furthermore, Melzer's reagent was used. Samples were observed through an optical Carl Zeiss microscope and all the measurements were made with the oil immersion objective (100×). Basidiospores, 30 from each basidioma, were measured in lateral view. The notation [a/b/c] at the beginning of a set of basidiospore measurements represent the following: (a) number of basidiospores measured from (b) basidiomata taken from (c) collections. Q-value represent the range of the length/width quotient for all basidiospores measured, Qm the average

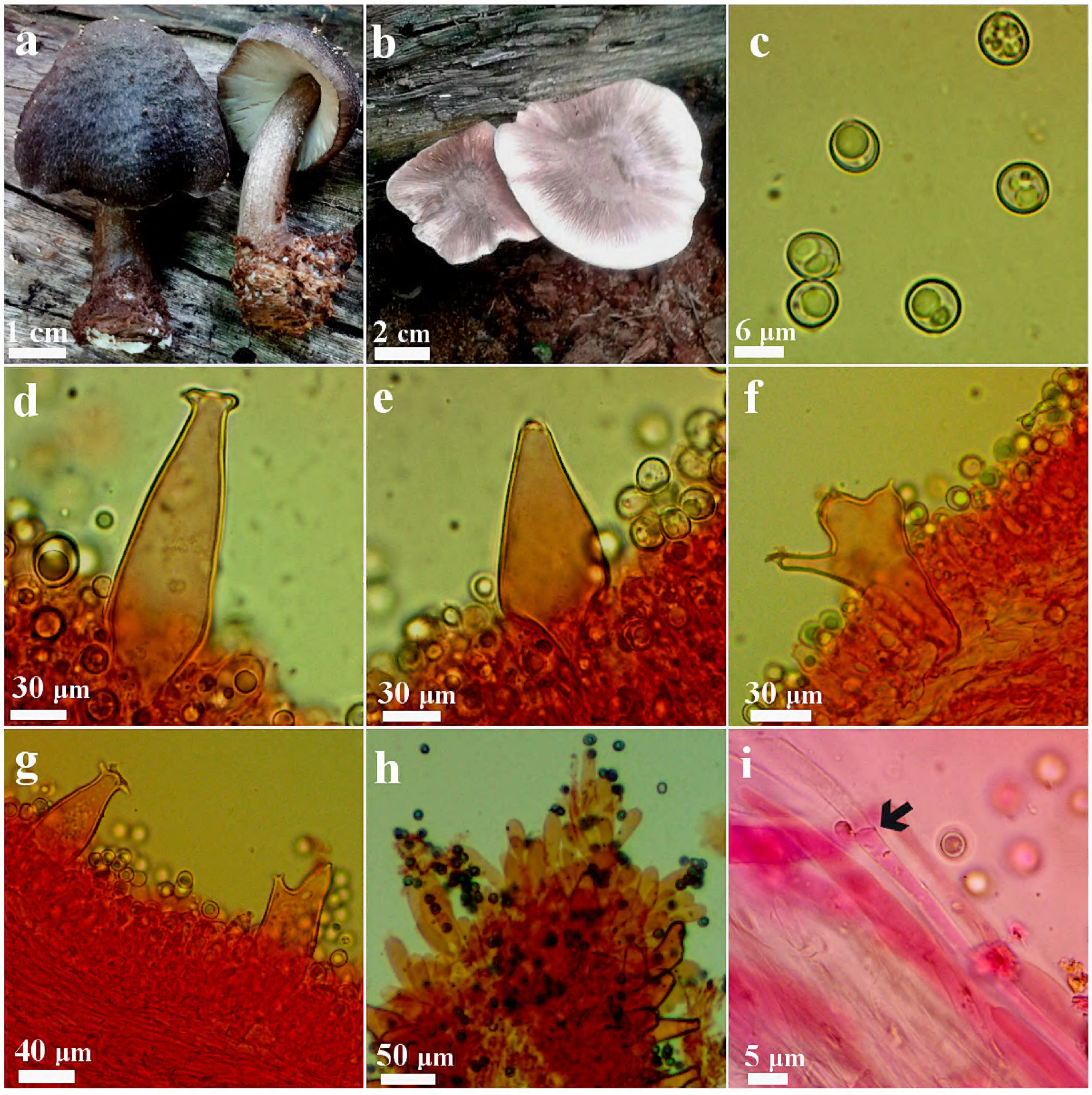

Figure 2. *Pluteus fibulatus* (leg. M. Campi 273). a, b. Basidiomata. **c.** Basidiospores. **d.** Metuloid pleurocystidium with short lateral prongs. **e.** Pleurocystidium of the Magnus-type. **f, g.** Pleurocystidium with bifurcations and apical prongs. **h.** Cheilocystidia. **i.** Pileipellis hyphae with clamp connection (arrow).

of all Q-values computed for all basidiospores measured, and Lm (Wm) represent the average of all lengths (widths) of the basidiospores. Basidiospore shape was based on the Q-value, according to Bas (1969). The specimens examined are stored at the Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Asunción Herbarium (FACEN).

Results

Pluteus fibulatus Singer, in Singer & Digilio, Lilloa 25: 252 (1952) [1951]

Figure 2

Material examined. Paraguay: Central Department, San Lorenzo city, Universidad Nacional de Asunción Campus (25°20′01.9″ S, 057°30′59.25″ W), 8 March 2018, M. Campi 273 (FACEN 004085).

Description. Pileus 4.5–8.5 cm in diameter, campanulate to slightly conic when young (1.5–2 cm in diameter), later plane-convex, dark gray to black when young, later becoming brown, lighter towards the margin, radially striate, margin entire. Context thin, whitish. Lamellae free, close, pinkish, lamellulae of 3 lengths. Stipe 5–7 × 0.5–1 cm, central, gray, longitudinally striate, cylindrical, slightly attenuated upward, with a bulbous base 1.5–2 cm diam. Odor and taste not recorded. Basidiospores [60/2/1] (5.9–) 6.4–7.9 × 5.8–7.1 (–7.7) µm [Q = 1.10–1.14; Qm = 1.12; Lm = 7.5; Wm = 6.8], subglobose, hyaline, inamyloid, smooth, thick-walled. Basidia 23–50 × 9–11 µm, tetraspored, sterigmata to 2.5 µm long,

clavate, thin-walled, hyaline. Pleurocystidia metuloid 67–96 (–108) × 21–27 (–32) µm, hyaline, rather abundant, broadly fusoid to utriform, thick-walled (0.9–1.4 µm thick), with 2–4 prongs, sometimes with wide lateral bifurcations or also of the *magnus*-type, with an acute apex and without prongs. Cheilocystidia 36–60 × 8–12.7 µm, clavate to cylindrical, hyaline, abundant, thin-walled. Lamellar trama inverse, composed of hyaline inflated hyphae, 10.2–14.3 µm in diameter, septate. Pileipellis a cutis, hyphae 8.6–32 µm in diameter, terminal elements of 64–115 × 6.8–13 µm, thin-walled, hyaline, sometimes filled with chestnut pigment. Caulocystidia not observed. Clamp connections present in the lamellar trama, pileus context, and pileipellis.

Habit and habitat. Gregarious, on a decaying trunk, in a forest remnant in the UNA Campus; found during the summer season.

Identification. *Pluteus fibulatus* was described from Argentina and classified in *Pluteus* sect. *Pluteus* because of the horned metuloidal pleurocystidia (Singer and Digilio 1952). It is also characterized by the presence of clamped hyphae and the fibrillose, dark colored pileus (Singer 1959). Singer (1959) did not mention the basidiospore shape in the description of the type. Menolli and Capelari (2014) re-examined the isotype from Argentina and found globose to broadly ellipsoidal (rarely ellipsoidal) basidiospores [20/1/1] (5.6–) 6.2–7.5(–8.7) × (5.0–)5.6–6.8(–7.5) µm [Q = 1.00–1.24(–1.40), Qm = 1.16, Lm = 7.1 µm; Wm = 6.1 µm], which resembled those found in the Paraguayan material. Menolli and Capelari (2014) described metuloidal pleurocystidia with 2–4 apical prongs, and pleurocystidia of the *magnus*-type were also found.

Pluteus fibulatus is similar to *P. spinulosus* because of similar macroscopic features, similar size of pileus and stipe, and both have a typical bulbous base of the stipe. They both have clamp connections in the trama, pileipellis and context as well as *Magnus*-type pleurocystidia (Singer 1956, Pegler 1983). However, *P. fibulatus* has globose basidiospores (Menolli et al. 2015a) in contrast with the subglobose basidiospores described for *P. spinulosus* (Singer 1956). In addition, *Magnus*-type pleurocystidia with lateral spinulose outgrowths towards the apex are described for *P. spinulosus* (Singer 1956, Pegler 1983), while *P. fibulatus* has *Magnus*-type and metuloid pleurocystidia (Menolli et al. 2015a) with bifurcations that bear apical spinules as observed in the Paraguayan material (Fig. 2f). Finally, *P. fibulatus* does not have cheilocystidia with distorted apical outgrowths and lateral spinulose outgrowths like *P. spinulosus*.

Pluteus longistriatus (Peck) Peck, Annual Report on the New York State Museum of Natural History 38: 137 (1885)

Figure 3

≡ *Agaricus longistriatus* Peck, Annual Report on the New York State Museum of Natural History 30: 40 (1878)

Material examined. Paraguay. Alto Paraguay Department, Bahía Negra city, Estación Biológica 3 Gigantes, Ariraí Path (20°04′ S, 058°09′ W), 26 June 2017, Yanine Maubet 059 (FACEN 004084).

Description. Pileus 2.7–3.7 cm in diameter, plane with a central depression, glabrous, dry, cream color when fresh, light chestnut when dry, surface radially fibrillose, with chestnut streaks, dark at center and discoloring radially towards the margin, translucently from the lamellae, margin slightly striate. Context very thin (up to 0.3 cm), whitish. Lamellae free, crowded, pinkish, regular, with lamellulae of 2 sizes. Stipe 3.6–4.8 × 0.15–0.3 cm in diameter, cylindrical, whitish when fresh, light brown when dry, central to slightly lateral, slightly attenuated upward, dry, fibrillose, inserted into the substrate, with scarce basal mycelium. Odor and taste not recorded. Basidiospores [60/2/1] 6.0–8.8 × 5.0–6.8 µm, [Q = 1.27–1.28, Qm = 1.28, Lm = 7.7, Wm = 6.0], broadly ellipsoid, inamyloid, hyaline, smooth, thick-walled. Basidia 20–26 × 9–11, tetraspored, sterigmata up to 2 µm long, versiform to clavate, hyaline. Pleurocystidia non-metuloid (25–) 35–67 × 11–22 (–26) µm, lageniform to ventricose, sometimes obclavate, thin-walled, hyaline. Cheilocystidia 26–58 × 16–28 µm, globose to ventricose, hyaline, scarce. Lamellar trama inverse, interwoven hyphae, 2–5 µm in diameter, sometimes branched, thin-walled, septate. Pileipellis a hymeniderm, heteromorphic elements 41–106 × 16–42 (–46) µm, broadly clavate to ventricose, thin-walled, hyaline. Caulocystidia 26–45 × 9–18 (–22) µm, lageniform to clavate, thin-walled, hyaline. Clamp connections absent in all parts examined.

Habit and habitat. In small groups, on decayed wood in an advanced state of decomposition, in a seasonally freshwater swamp forest, during flood season in winter, in the Paraguayan Pantanal.

Identification. *Pluteus longistriatus* was classified in *Pluteus* sect. *Celluloderma* by Singer (1959) due to the pileipellis being composed of heteromorphic elements. However, based on molecular sequences, Justo et al. (2011b) placed *P. longistriatus* into *Pluteus* sect. *Hispidoderma*, which includes taxa with hymenidermal pileipellis. Menolli and Capelari (2010), studying Brazilian materials and re-examining Singer's (1959) North American and Argentine collections, found caulocystidia in the stipe of some *P. longistriatus* specimens, although Singer (1959) had not described them. The Paraguayan collection presented caulocystidia, although they were smaller than those found by Menolli and Capelari (2010) in the Brazilian [(42–) 70–120 (–134) × 20–34 µm] and the North American collections [(24–) 48–82 (–88) × (–10) 14–34 (–38) µm]. The Brazilian and North American materials had basidiospores similar in size (6.2–8.7 × 5.0–7.5 µm, according to Menolli and Capelari 2010) to those found in the Paraguayan material. Menolli and Capelari (2010) pointed out that the pleurocystidia from the North American collections were longer [(38–) 42–106 (–114) × (10–)

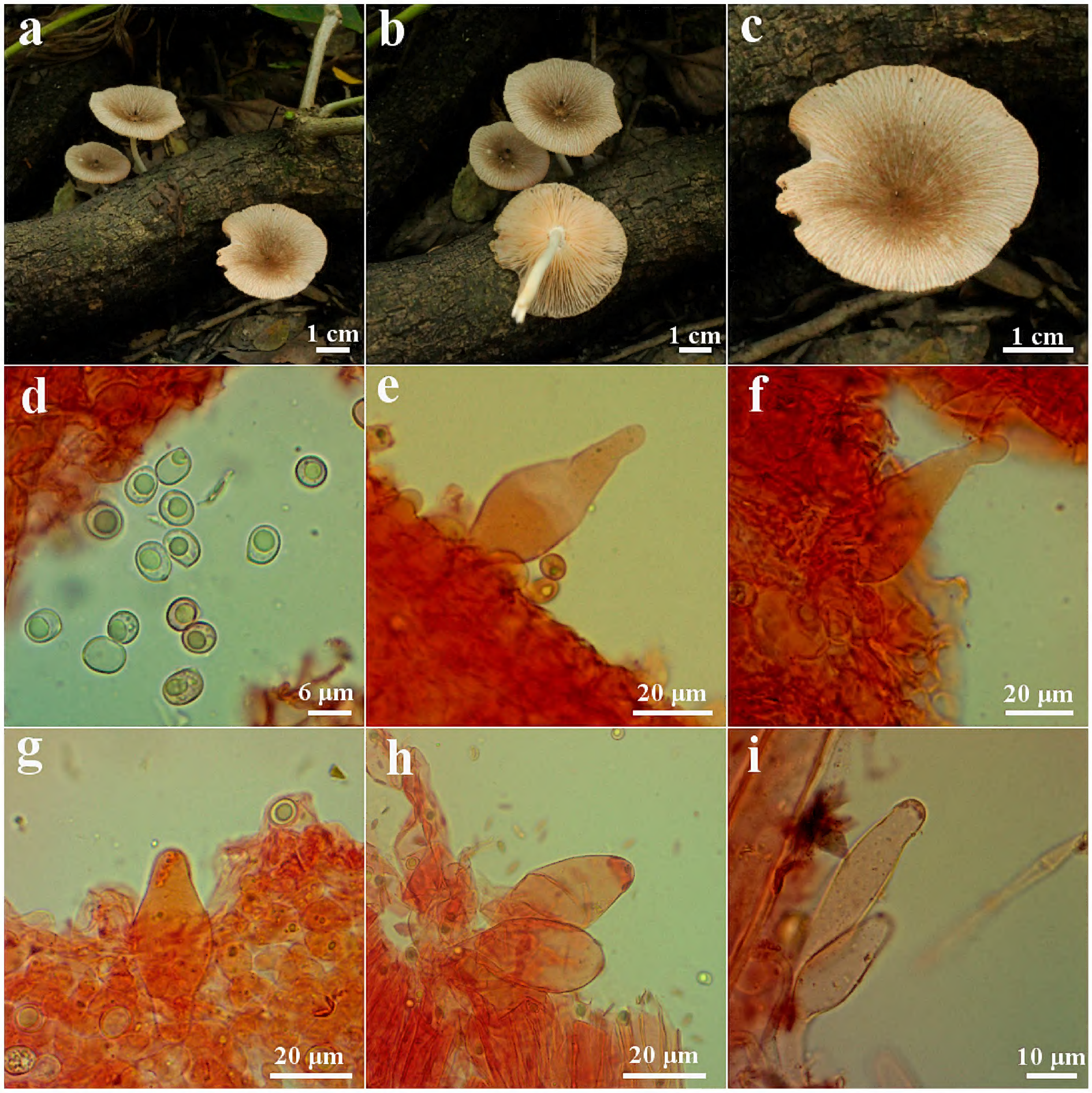

Figure 3. *Pluteus longistriatus* (leg. Y. Maubet 059). **a–c.** Basidiomata. **d.** Basidiospores. **e, f.** Pleurocystidium. **g.** Cheilocystidium. **h.** Hymenidermal elements of the pileipellis. **i.** Caulocystidium.

14–30 (–38) µm] than those from the Brazilian collections [(45–) 50–71 (–81) × (8.7–) 10–24 (–29) µm], which were similar in size to those found in the Paraguayan material. The typical pileipellis composed of heteromorphic elements was found in our material and fits the previous descriptions for *P. longistriatus* (Singer 1959, Menolli and Capelari 2010). Justo et al. (2011b) discussed that *P. heteromarginatus* Justo was morphologically similar to *P. longistriatus* differing only in the shape of the pleuro-, cheilo-, and caulocystidia. *Pluteus heteromarginatus* has pleurocystidia with elongated apexes or an apical flexuous excrescence (5–10 µm long), cheilocystia (narrowly) clavate, narrowly utriform, or more rarely obovoid, and fusiform or lageniform caulocystidia (Justo et al. 2011b).

Pluteus sanctixavierii Singer differs mainly in the composition of the pileipellis; *Pluteus longistriatus* has a layer of vesiculose to fusoid cells intermixed with elongate-fusiform to elongate-clavate dermatocystidia (to 150 µm long) (Menolli and Capelari 2010), while the pileipellis of *P. sactixavierii* is composed of sphaerocysts and slightly vertically elongated elements of much smaller dimensions (to 72 µm long) and mostly isodiametric (Singer 1959).

Pluteus petasatus (Fr.) Gillet, Les Hyménomycètes ou Description de tous les Champignons qui Croissent en France: 395 (1876)

Figure 4

≡ *Agaricus petasatus* Fr., Epicrisis Systematis Mycologici: 142 (1838)
≡ *Pluteus cervinus* var. *petasatus* (Fr.) Fr., Hymenomycetes europaei: 186 (1874)

Material examined. Paraguay. Central Department, Guarambaré city (25°29′ S, 057°27′ W), 29 June 2018, M.

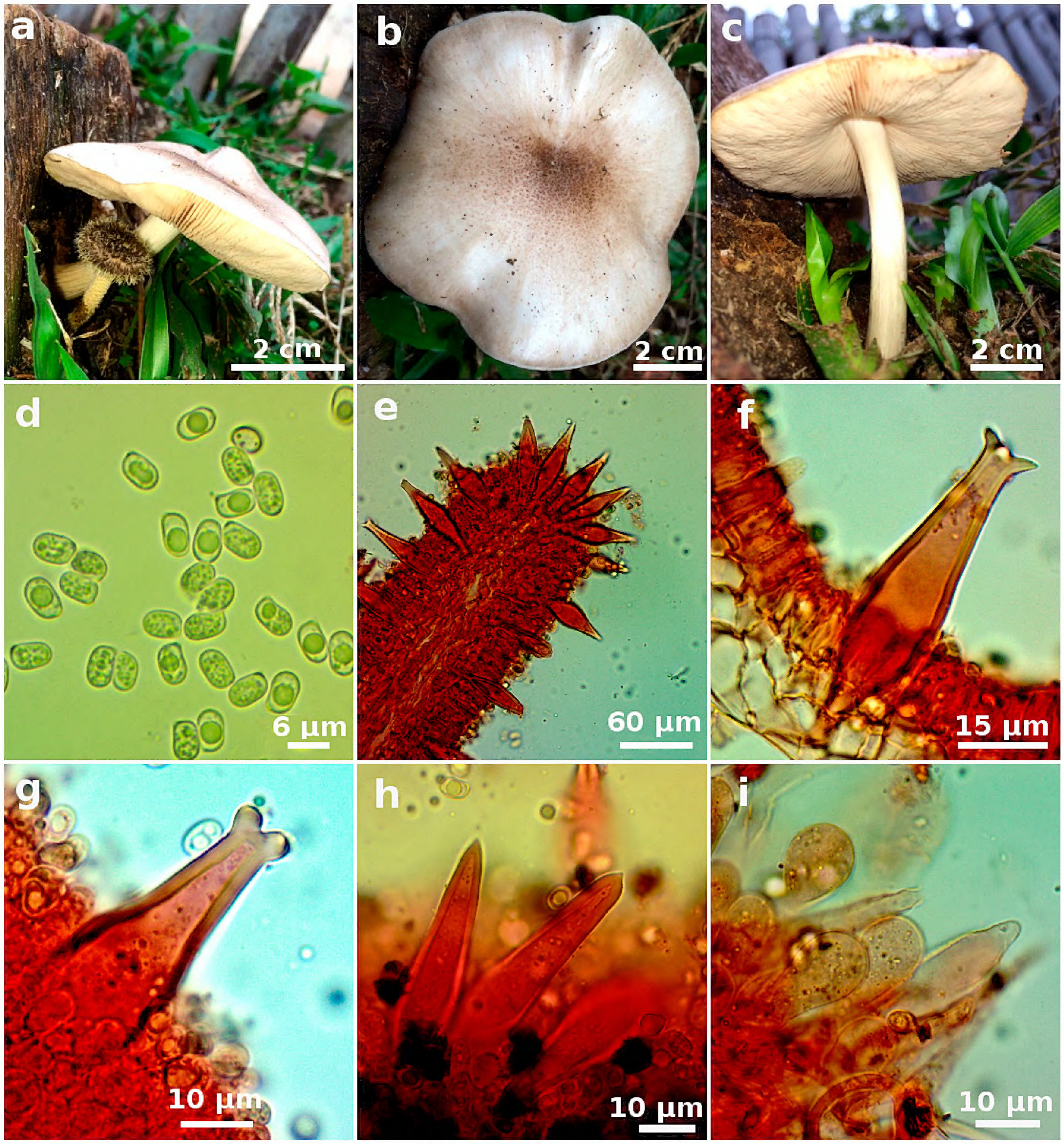

Figure 4. *Pluteus petasatus* (leg. M. Campi 293). **a–c.** Basidiomata. **d.** Basidiospores. **e–h.** Metuloidal pleurocystidium. **e.** Pleurocystidium of the magnus-type near the edge of the lamellae. **f, g.** Metuloidal pleurocystidium with lateral prongs. **h.** Metuloidal pleurocystidia of the magnus-type. **i.** Cheilocystidium.

Campi 293 (FACEN 004082).

Description. Pileus 4–6 cm in diameter, convex and umbonate when young, plane-convex when mature, cream-colored to grayish, with tiny brownish scales concentrated in the disk and attenuate towards the margin, radially fibrillose, margin entire, darker and undulated when mature. Context thin, whitish. Lamellae free, crowded, whitish when fresh, pinkish at maturity, lamellulae of 3 sizes. Stipe 4–4.8 × 0.5–0.7 cm, slightly excentric, solid, glabrous, slightly attenuated upward, pearly white with dark gray fibrils towards the base. Odor strong, slightly unpleasant, taste not recorded. Basidiospores [60/2/1] (5.5–) 6.0–7.0 (–7.5) × 4.0–4.5 µm, [Q = 1.6–1.6, Qm = 1.6, Lm = 6.4, Wm = 4.1], ellipsoid to elongate, inamyloid, hyaline, smooth, thin-walled. Basidia 23–33 × 6–9 µm, tetraspored, sterigmata up to 3.3 µm long, claviform, hyaline. Pleurocystidia metuloid 61–76 (–80) × 12.5–18 (–21.5) µm, abundant, thick-walled (to 2–3 µm thick), with 2–4 lateral prongs, some of the *magnus*-type, 46–62 × 10.0–18.0 µm, also present and abundant in the lamellae edge, hyaline. Cheilocystidia 36–61 × 8.4–12.2 µm, clavate, hyaline, thin-walled, scarce. Lamellar trama inverse, interwoven hyphae, 2.2–16.3 µm in diameter, septate, thin-walled. Pileipellis a cutis, hyphae 3.5–8 µm in diameter, with

terminal elements 64–89 × 6–12 µm, some strongly tapering towards apex, thin-walled, hyaline or filled with brown intracelular pigment. Caulocystidia not seen. Clamp connections absent in all parts examined.

Habit and habitat. Solitary on rotting trunk, in urban area, collected during the winter.

Identification. *Pluteus petasatus* is a morphologically variable species in terms of macroscopic characters, comprising specimens with smooth and viscous to scaly and dry pileus, varying from white to brown or gray (Vellinga 1990, Justo et al. 2014). These morphological variations gave rise to several synonyms, including *P. curtissi* (Berk.) Sacc., *P. patricius* (Schulzer) Boudier, *P. magnus* McClatchie, *P. australis* Murrill, and *P. viscidulus* (Justo et al. 2014). To understand the taxonomy of *P. petasatus* some authors carried out morphological and molecular studies with samples from different geographic origins (Justo and Castro 2007, Justo et al. 2011a, b, 2014, Menolli and Capelari 2014). Justo et al. (2014), using a combined dataset based on ITS and *tef1* sequences, recovered the "petasatus clade", which includes *P. petasatus*, *P. pellitus* (Pers.) P. Kumm., and *P. leucoborealis* Justo, E.F. Malysheva, Bulyonk. & Minnis. These 3 species grow mainly on angiosperm wood and humus. Of them, *P. petasatus* is relatively common in urban and ruderal areas (Justo et al. 2014); *P. pellitus* is distinguished mainly by the clamp-connections on pileipellis hyphae, and *P. leucoborealis* seems to be confined to boreal forests, only recorded on *Betula* and *Alnus* (Justo et al. 2014). Justo et al. (2011b) considered *P. viscidulus* to be a synonym of *P. petasatus*, based on molecular data from the holotype of *P. viscidulus* from Argentina. Later, Justo et al. (2014) confirmed that Argentine samples correspond to *P. petasatus*. Menolli and Capellari (2014) reviewed a Brazilian sample that Singer (1959) had determined as *P. viscidulus* and concluded that it corresponds to *P. petasatus*. The Paraguayan collection presented all the diagnostic characters described for *P. petasatus* by Justo and Castro (2007), Justo et al. (2011a, b, 2014), and Menolli and Capelari (2014), such as the presence and predominance of the *magnus*-type pleurocistydia near the edge of lamellae, the scarce cheilocystidia, and the lack of clamp connections on pileipellis hyphae.

Pluteus triplocystis Singer, Beihefte zur Sydowia 7: 63 (1973)

Figure 5

Material examined. Paraguay, Central Department, San Lorenzo city, Universidad Nacional de Asunción, (25°33′ S, 057°52′ W), 28 March 2017, M. Campi 265 (FACEN 004083)

Description. Pileus 7.5–9.5 cm in diameter, plane with central umbo to convex, glabrous, grayish to brown when young, brownish-gray when mature, margin entire, undulating when mature. Context whitish. Lamellae free, crowded, whitish when young, pinkish at maturity, with lamellulae of 3 sizes. Stipe 5.5–10 × 1–1.3 cm, central, hollow, fibrillose, pearly color, becoming darker towards the base, straight to flexuous, attenuated upwards, with white mycelium at base. Odor and taste not recorded. Basidiospores [60/2/1] (6.0–) 6.5–7.0 (–7.5) × 5.8–7.0 µm, [Q = 1.07–1.13; Qm = 1.10; Lm = 6.9; Wm = 6.3], subglobose, hyaline, inamyloid, gutulate, thin-walled, smooth, with a short apiculum. Basidia 18.1–27 (–29) × 7.7–11.1 µm, tetraspored, clavate to slightly ventricose, hyaline, thin-walled, with basal clamp connection. Pleurocystidia metuloid 61–88 × 15.3–19.5, thick-walled, with short lateral prongs, without central prongs, reaching the lamellar edge, some of the *magnus*-type, with a subacute apex, hyaline. Cheilocystidia 21–52 × 8–15 µm, clavate to cylindrical, hyaline to yellowish, thin-walled, numerous, with basal clamp connection. Lamellar trama inverse, 35–39 µm thick, hyphae7–12 µm in diameter, thin-walled, septate. Pileipellis a cutis, hyphae 5–10 µm in diameter, thin-walled, hyaline, some with brown content. Caulocystidia 44–85 (–100) × 12–19 µm, subfusiform, with brownish-yellow pigment, in fascicles, with basal clamp connection. Clamp connections present in the lamellar trama, pileus context, pileipellis, cheilocystidia, basidia and caulocystidia base.

Habit and habitat. Gregarious, on decaying trunk, in an anthropologically modified forest remnant in the UNA Campus, found in autumn.

Identification. The type of *P. triplocystis* was described with a gray, convex-campanulate pileus (4 cm in diameter); basidiospores ranging 5.5–7.5 × 4.5–5.5 µm in young specimens; hyaline, metuloidal pleurocystidia with 1–3 prongs or without prongs and with an acute apex; ventricose, subcylindric to claviform cheilocystidia; pileipellis a cutis; and clamp connections present in the base of the pleuro- and cheilocystidia (Singer 1973, Rodríguez et al. 2004). In general, the Paraguayan material fits the protologue of Singer (1973) and also the description of the holotype as re-examined by Rodríguez et al. (2004), although the pileus and the basidiospores of the specimens from Paraguay were larger than the type from Mexico; the type most likely was a young specimen (Singer 1973). Rodríguez and Guzmán-Dávalos (2007) noted that *P. martinicensis* Singer & Fiard is a morphologically similar species that differs from *P. triplocystis* in the basidiospores size, 6–7.6 (–8) × (5.2–) 5.6–6.8 (–7.6) µm, or 5–7 × 4.5–6 µm according to Pegler 1983. According to Rodríguez and Guzmán-Dávalos (2007), *P. triplocystis* has more inflated metuloidal pleurocystidia with shorter horns and clamp connections are present in all micromorphological structures. Rodríguez (2013) pointed out that *P. martinicensis* only bears clamp connections in the pileipellis and stipitipellis hyphae and that it represents the main difference between both species. Another well-known feature to distinguish these species is the presence of cheilocystidia with brown content in

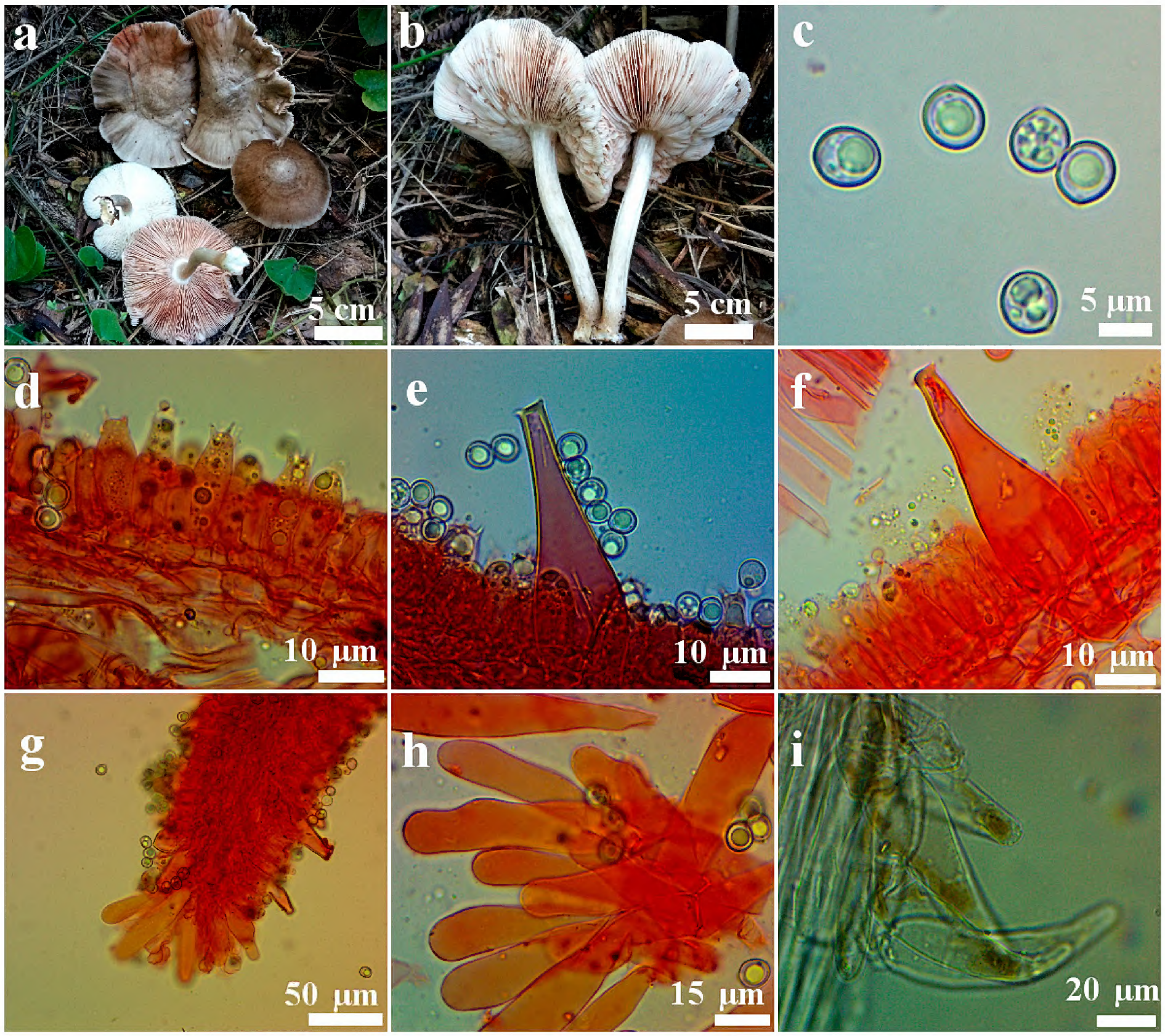

Figure 5. *Pluteus triplocystis* (leg. M. Campi 265). **a, b.** Basidiomata. **c.** Basidiospores **d.** Basidia. **e, f.** Metuloidal pleurocystidium. **g, h.** Cheilocystidia and Caulocystidias. **i.** Caulocystidium.

P. martinicensis (Pegler 1983, Pradeep et al. 2002, Justo and Castro 2007), whereas in *P. triplocystis* the cheilocystidia are completely hyaline (Singer 1973). Additional collections and molecular studies are needed to establish the relationship among *P. martinicensis* and *P. triplocystis*. Based on the presence of clamp connections in all micromorphological structures, such as cheilocystidia, pleurocystidia, caulocystidia, basidia and in the pileipellis along with the hyaline cheilocystidia, we conclude that the Paraguayan specimens correspond better to the concept of *P. triplocystis* than to *P. martinicensis*.

Discussion

Pluteus fibulatus is a species restricted to South America, found in Argentina, Brazil, and now Paraguay. From Brazil, it was recorded from the states of Paraná (Stijve and de Meijer 1993, de Meijer 2006, Menolli et al. 2015a), Rio Grande do Sul (Singer and Digilio 1952, Singer 1954b), and São Paulo (Pegler 1997), and from Argentina it was recorded from the province of Tucumán (Raithelhuber 1987, 1991, Singer 1956, 1959, Singer and Digilio 1952).

Pluteus longistriatus, on the other hand, was described from Albany County, New York, USA (Peck 1885), and since then also it has been recorded from Argentina (Singer 1956, 1959), Brazil (Menolli and Capelari 2010, Gugliotta et al. 2012), northeastern USA (Longyear 1904, White 1910, Kauffman 1915, 1918, Murrill 1917, Morse 1918, Sumstine 1918, Singer 1959, Gilbertson et al. 1974, Branson 1989, Bates 2006, Menolli and Capelari 2010, Justo et al. 2011a, b), Canada (Groves and Macrae 1963) , Italy (Ferisin and Dovana 2016), Russia (Malysheva et al. 2016) and South Korea (Malysheva et al. 2016).

Pluteus petasatus has been recorded in Eurasia, North and South America, and Oceania (Justo et al. 2014). In Eurasia and Oceania there are records from the Netherlands, Spain, Switzerland, Russia, Mongolia, Japan, and Papua New Guinea (Vellinga and Arnolds 1990, Justo and Castro 2007, Justo et al. 2014). In North America, *P. petasatus* has been recorded across the USA in the states of California, Florida, Illinois, Louisiana,

Maine, Massachusetts, Michigan, Mississippi, Missouri, New York, Tennessee, and Wisconsin (Banerjee and Sundberg 1995, Justo et al. 2014), and in Mexico in the states of Jalisco, Sinaloa, Sonora, and Queretaro (Esqueda-Valle et al. 1995, Rodríguez 1998, Rodríguez and Guzmán-Dávalos 2001, Rodríguez 2013). Finally, in South America, there are records from Argentina and Brazil as *P. viscidulus* Singer (Singer and Digilio 1952, Singer 1959), which was later considered as synonym of *P. petasatus* (Justo et al. 2011b, 2014). Finally, *Pluteus triplocystis* had been described from Mexico by Singer (1973) and is only known from the type locality.

These 4 species are the first records of the family Pluteaceae from Paraguay, and for *Pluteus triplocystis,* the first record from South America. Our study is the first attempt in Paraguay to find and document records of the practically unexplored family Pluteaceae, which has been fairly well studied elsewhere in South America. This is only the second documentation of fungi from the Paraguayan Pantanal, one of the less explored areas in the Paraguayan Chaco.

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Authors' Contributions

MC, YM, and EC collected the materials; MC, YM, and NMJr identified the species; MC and YM did the morphological description of the material; MC, YM, and EG helped in formatting and writing the manuscript, and NMJr helped in the correction of the manuscript.

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